Flood Mapping over the Asian Continent during the 1999 Summer Monsoon Season

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Abstract – Backscatter data from the SeaWinds scatterometer on the QuikSCAT satellite are used to delineate floods over the Asian continent. SeaWind acquires Ku-band (13.4 GHz) data at the vertical polarization over a very large swath of 1800 km, and at the horizontal polarization over a 1400-km swath. We present the flood areas together with topography on land and wind field on ocean. Results show extensive flood in China, India, Bangladesh, and other Asian countries. Timely flood mapping can provide crucial information for flood relief efforts.

INTRODUCTION

Severe floods occur frequently in Asian monsoon regions. Monsoon winds blowing inland from the ocean compounding with the tropical humid-temperature climate result in heavy monsoon rains. The landward winds also push the ocean water against river outlets, slow down discharge rates, and thus curtail the outflux of flood water. Moreover, regional topographic characteristics with large flood plains and extended subsided terrain make it susceptible to flooding.

Devastating floods over the Asian subcontinent have caused loss of lives, extensive property damages, food shortages, and disease outbreaks. In these developing countries, the infrastructure is not well developed to cope with flood disasters in a timely manner. Equipment and weather stations to collect necessary data are not sufficiently available and the communication technology is limited. Conventional methods to compile flood information involve manual collection and collation of point data. These processes are time consuming and report output often take years to complete.

Floods are transient weather events taking place in a matter of days or even shorter. For effective flood management, timely information on flooding over a large areal coverage is necessary. A spaceborne Ku-band scatterometer, an accurate radar, with a large swath can provide near daily global coverage with the capability to see through clouds and darkness. In this paper, we present an innovative technique for delineation of flood inundation over cropland and urban areas [1] using scatterometer data.

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METHODOLOGY

Various sensors have been applied to flood mapping. Aircraft reconnaissance for synoptic coverage of flood inundation is dependent on weather conditions, expensive, and limited in areal coverage. For visible and infrared sensors such AVHRR, thick and widespread cloud cover accompanying the wet phase of the monsoon cycle limits its application. SSM/I has been used to derive an indicator of wetness; however, multi-frequency passive data have low resolution with high atmospheric effects. SAR has a very high resolution but the swath and coverage are small. A spaceborne wideswath scatterometer can see through clouds and darkness, has a higher resolution than radiometer, and a larger swath than SAR.

Our flood delineation approach utilizes an innovative technique based on the polarization reversal of radar backscatter over flooded areas. When the landscape becomes flooded, the reflection becomes strong due to the large permittivity of the underlying water and backscattering is dominated by the reflection terms. In this case, σ_{VV}/σ_{HH} is less than 1 in the linear scale or negative in the dB scale in reverse to the dry cases. It is noted that the total absolute backscatter may or may not change significantly because the direct scattering terms can decrease due to submerged volume and surface scatterers while the reflection terms increase. Thus, backscatter change alone may or may not be a good indicator of flooding. Our method is based on the relative polarization ratio, not on the absolute backscatter values.

QUIKSCAT/SEAWINDS DATA

The QuikSCAT satellite was successfully launched at 7:15 p.m. Pacific Daylight Time on 19 June 1999 from the Vandenberg Air Force Base in California. The satellite carries the SeaWinds scatterometer for ocean wind measurements [2]. The scatterometer has been collecting data at 13.4 GHz on both ocean and land. Backscatter data, at a radiometric resolution tion of 7 km × 25 km, are acquired with the vertical polarization (σ_{VV}) at a constant incidence angle of 54° over a conical-scanning swath of 1800 km, and with the horizontal polarization (σ_{HH}) at 46° over a 1400-km swath.

We colocate the dual polarization data, which cover the entire Asian continent in 2.5 days. The local overpass times are around 6:20 and approximately 12 hours apart in a sun-synchronous orbit. The satellite orbit was stabi-

lized, the scatterometer performance was verified, and the calibrated science data have been obtained since 19 July 1999 [3]. Note that the incidence angle of the vertical-polarization data is taken out to a larger angle compared to the incidence angle of the horizontal-polarization data. In effect, the separation of the incidence angles in this manner enhances differences between the two different polarizations in the flooded case.

FLOOD MAPPING RESULTS

QuikSCAT/SeaWinds scatterometer has been collecting science data since July 1999 at the time when strong cyclones and severe widespread floods started to occur, early this year, over various countries in the Asian summer monsoon region. Heavy monsoon rains since June devastated large areas of Asia this summer.

QuikSCAT/SeaWinds backscatter data acquired over Asia show extensive floods in Anhui, Zhejiang, Jiangsu, and other provinces in the Yangtze river basin. According to reports from the United Nations Office for the Coordination of Humanitarian Affairs (UN-OCHA), 100 million people in China were affected by this year's floods [4]. QuikSCAT/Sea-Winds data over India reveal the North Bihar flood. Triggered by torrential monsoon rains, this flood was the worst in more than a decade and it affected 5 million people and inundated more than 2700 villages over 21 districts [5].

Since July, the scatterometer flood mapping indicates the flood situation in India has been worsened and spanned extensive regions from West Bengal, through Bihar, to Uttar Pradesh, and up to Himachal Pradesh. Later in October 1999, QuikSCAT/SeaWinds wind and flood time-series observations show a cyclone forming over ocean, moving toward land, making landfall, and causing extensive floods in the state of Orissa in eastern India making 10 million people homeless.

In Bangladesh, the flooding got worse as indicated by QuikSCAT/SeaWinds data. Further intensification of the monsoon brought heavy downpours throughout most of Bangladesh which led to significant rises in major rivers, floods, and severe erosion, as indicated by the International Federation of Red Cross (IFRC) [6]. Monsoon floods are also observed over many Asian countries including Nepal, Pakistan, Vietnam, Laos, Thailand, and Cambodia with the worst flooding in 20 years.

While the flood mapping results show a cause-and-effect relationship between winds and floods, it is also important to map a flood when it has already occured. This is exactly when the crucial efforts of flood relief start. By delineating the flood areas, one can integrate the population density over the affected areas and can calculate the number of people affected. Gridded digital data on population of the world [7] are available for such application.

Timely flood mapping gives information on the "when, where, how large, and how many", which are important to flood relief organization such as UN-OCHA, IFRC, and national and local authorities to determine and allocate limited resources (food, medicine, and personnel) to flood areas. Furthermore, the flood mapping is important for regional hydrological studies, and for agricultural and urban planning and development.

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